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Groell

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(54) **PROBE AND METHOD FOR OPERATING A PROBE**

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G01B 7/012 (2006.01)
G01B 21/04 (2006.01)

(52) **U.S. Cl.**
CPC ***G01B 7/012*** (2013.01); ***G01B 21/047*** (2013.01); *G01B 2210/58* (2013.01)

(58) **Field of Classification Search**
CPC G01R 31/026; G01R 31/1236
USPC 324/111; 320/166
See application file for complete search history.

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(57) **ABSTRACT**

A probe is configured such that an output current pulse is able to be delivered by the charge storage at defined intervals to a load. A mean power to be fed to the charge storage is ascertainable for a subsequent time interval, and the level of the mean input power, which is to be drawn by the voltage transformer from the power source, is specifiable as a function of the ascertained mean power. The voltage transformer is controllable accordingly.

5 Claims, 7 Drawing Sheets

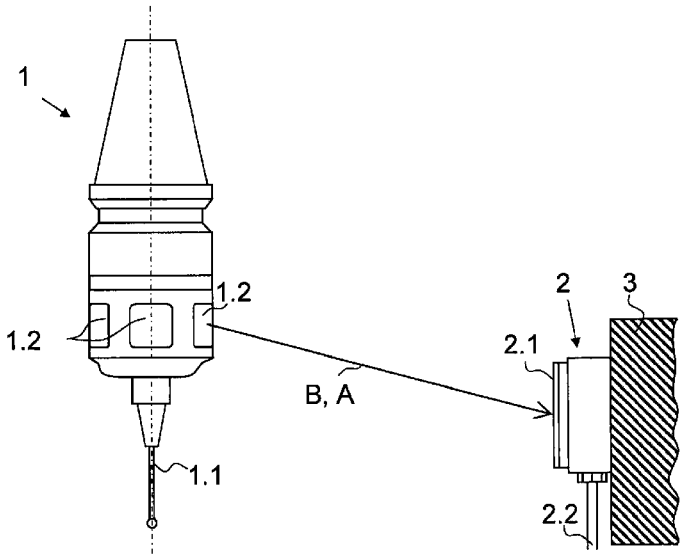


FIG. 1

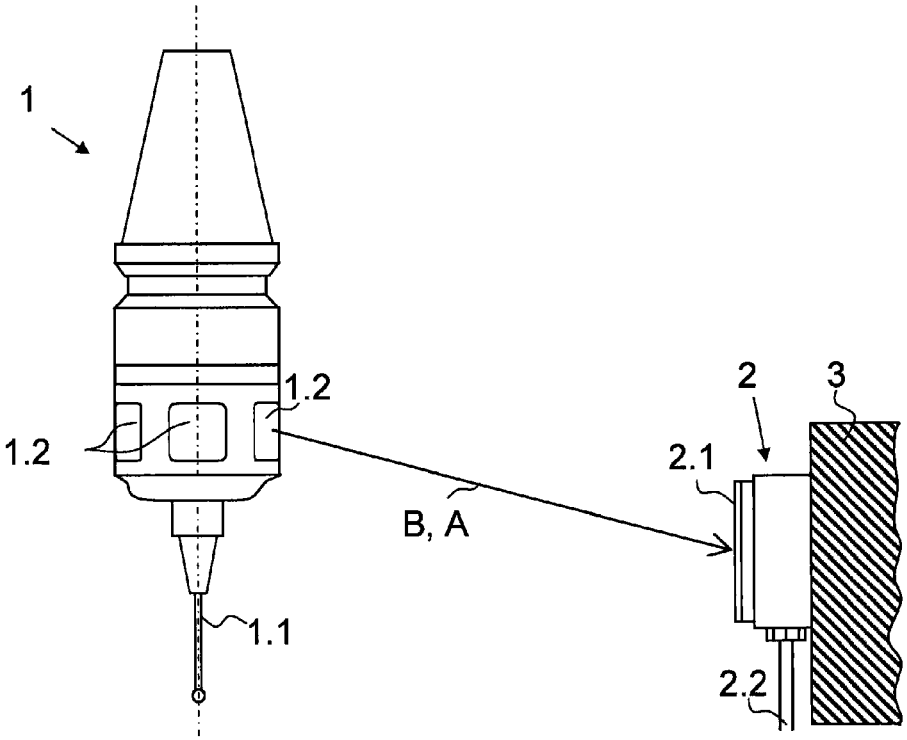


FIG. 2a

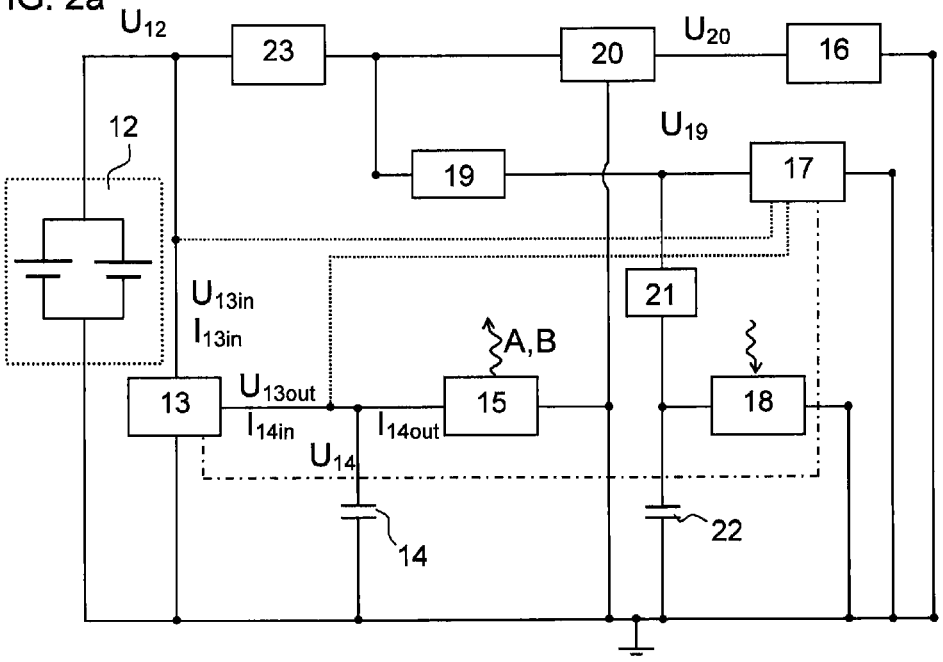

U12
23
20
U20
16
12
U19
19
17
U13in
I13in
21
A,B
13
U13out
I14in
15
I14out
18
U14
14
22

FIG. 2b

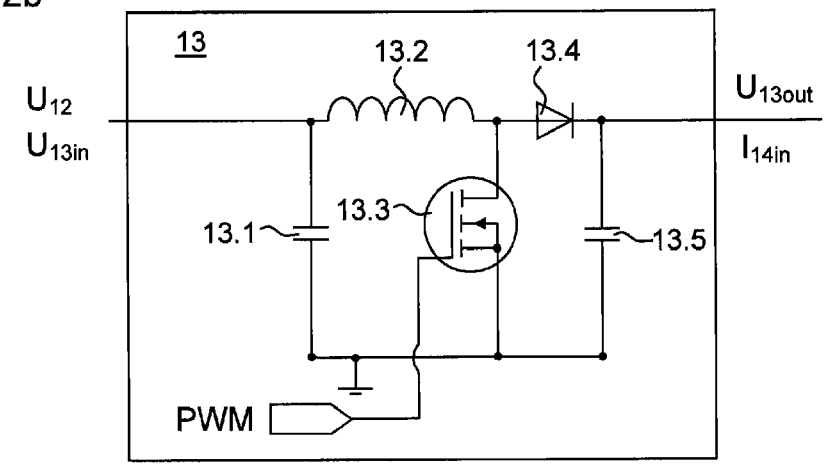

13
13.2
13.4
U12
U13in
U13out
I14in
13.1
13.3
13.5
PWM

FIG. 3a

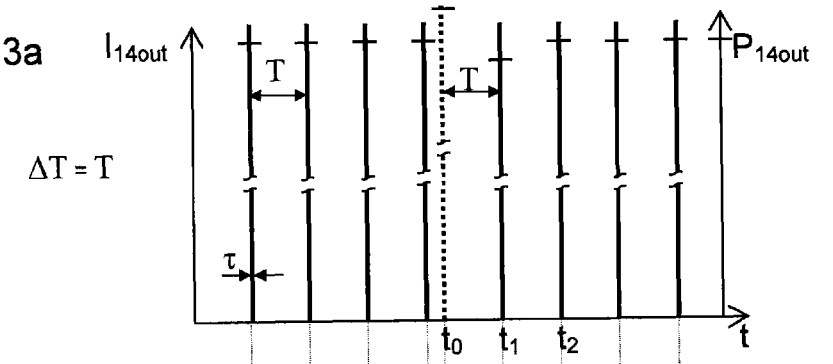


FIG. 3b

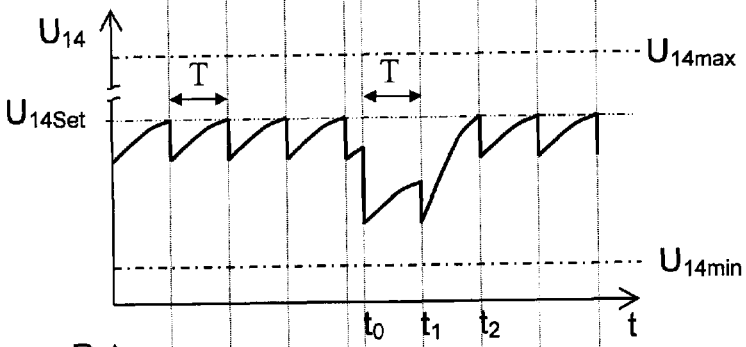


FIG. 3c

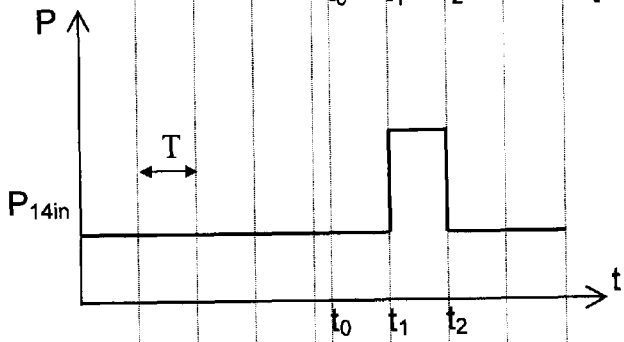


FIG. 3d

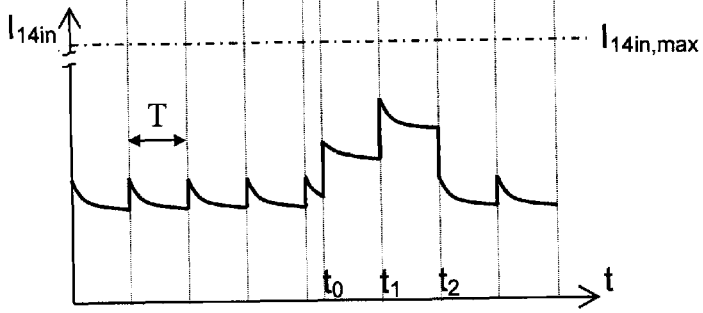


FIG. 4a

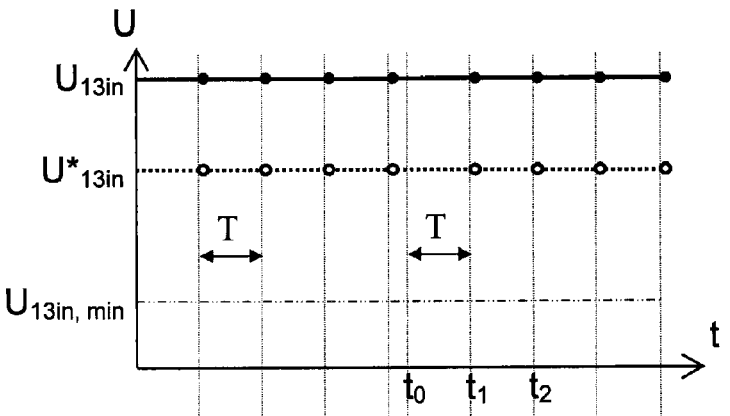


FIG. 4b

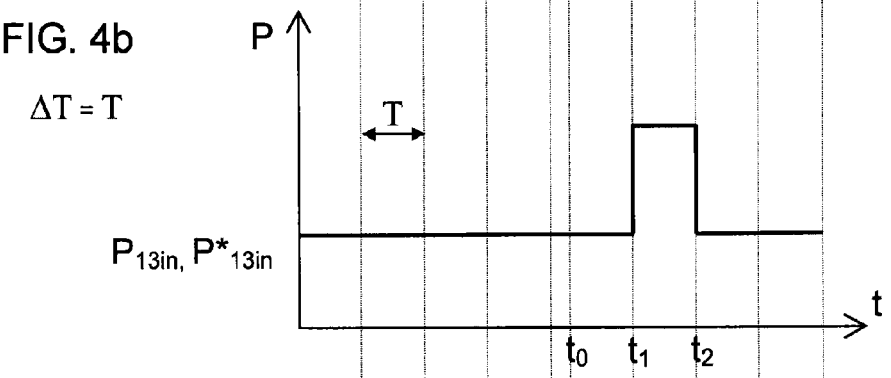


FIG. 4c

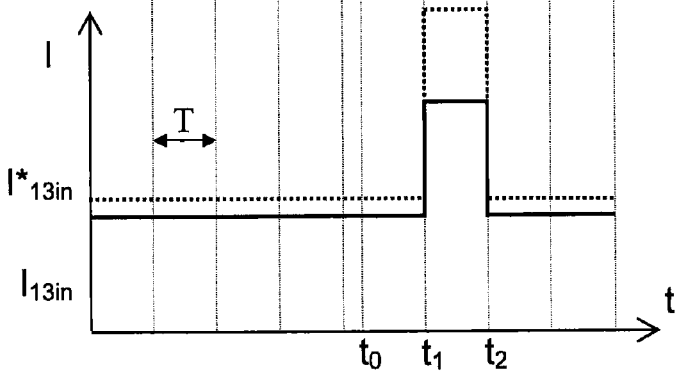


FIG. 5a

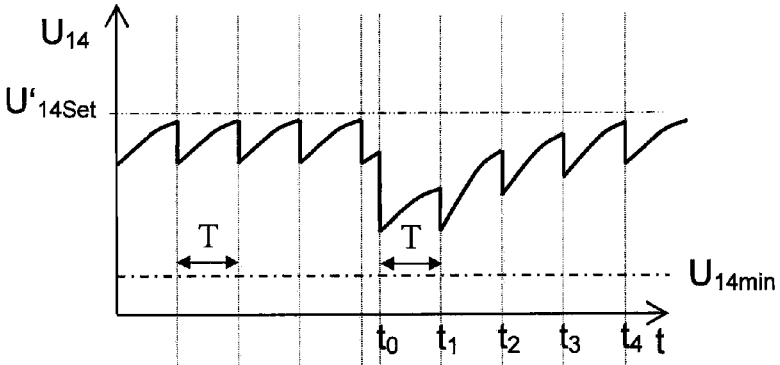


FIG. 5b

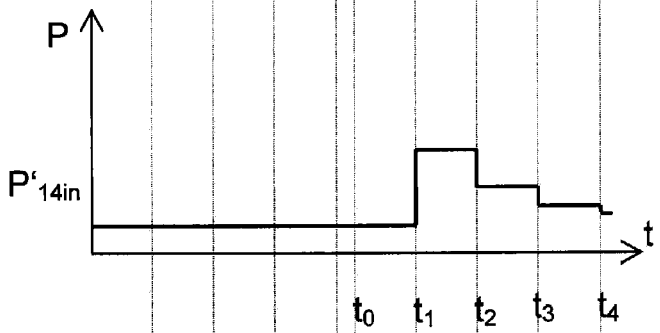


FIG. 5c

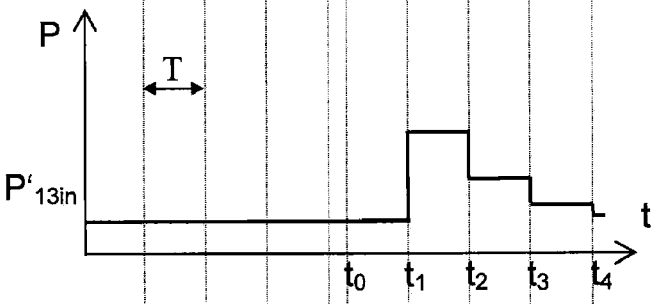


FIG. 5d

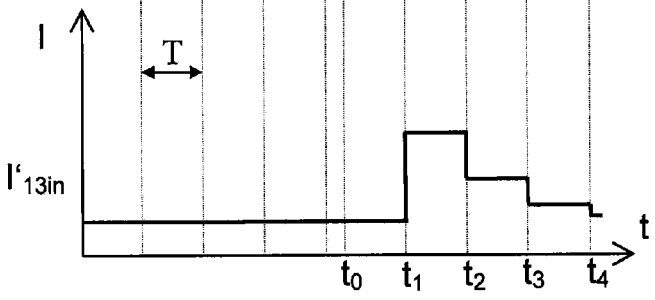


FIG. 6a

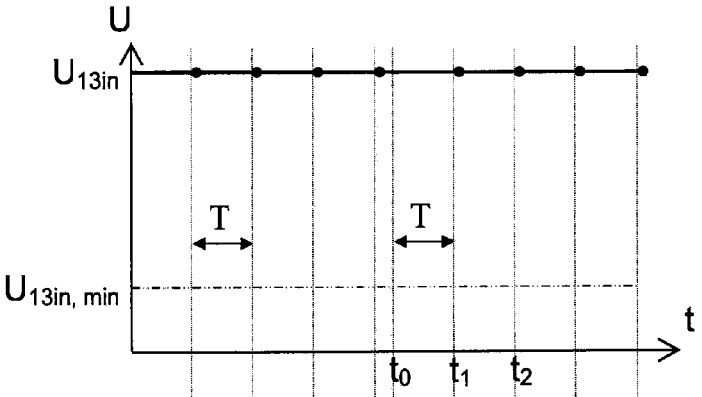


FIG. 6b

$\Delta T = T$

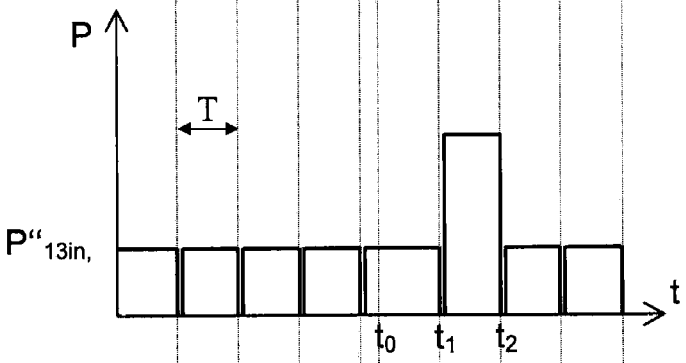


FIG. 6c

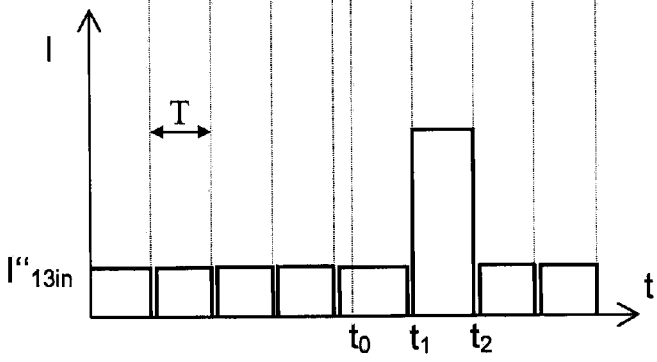
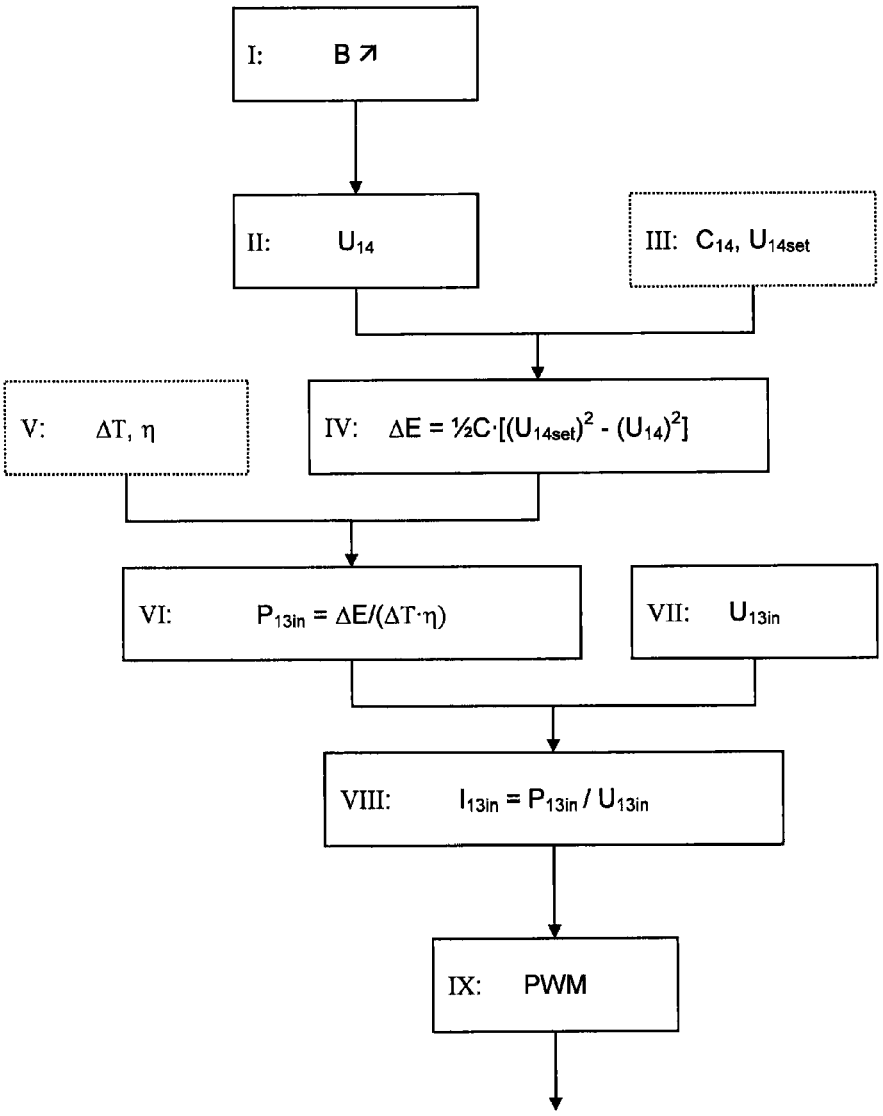


FIG. 7


I: B↗
II: U_{14}
III: C_{14}, U_{14set}
V: ΔT, η
IV: $\Delta E = \frac{1}{2}C\cdot[(U_{14set})^2 - (U_{14})^2]$
VI: $P_{13in} = \Delta E/(\Delta T\cdot\eta)$
VII: U_{13in}
VIII: $I_{13in} = P_{13in} / U_{13in}$
IX: PWM

PROBE AND METHOD FOR OPERATING A PROBE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to Application No. 10 2011 006 017.0, filed in the Federal Republic of Germany on Mar. 24, 2011, and to Application No. 10 2011 084 755.3, filed in the Federal Republic of Germany on Oct. 19, 2011, each of which is expressly incorporated herein in its entirety by reference thereto.

FIELD OF THE INVENTION

The present invention relates to a probe and to a method for operating a probe.

BACKGROUND INFORMATION

Probes are used, for example, to determine the positions of workpieces which are clamped in material-working machines, such as milling machines. A probe is usually a component of a probe system that often has a stationary transceiver unit. The transceiver unit is normally secured to an immovable element of the material-working machine. The probe may be mounted on a movable element of the material-working machine, for instance, on a milling spindle. In this context, the probe includes a feeler or probe element that is deflectable out of a rest position and that generates a switching signal in response to a deflection out of its rest position. Rest position of the probe element should be understood to be a position of the probe element in which it has no contact with a workpiece. In response to contact of the probe element with the workpiece, the probe element is deflected out of its rest position.

In what are referred to as wireless probe systems, the corresponding switching signal is transmitted by the probe as an electromagnetic signal, especially as an infrared signal or radio signal, to the stationary transceiver unit. In the transceiver unit, the output signals of the probe system are analyzed in order to determine the occurrence of switching signals (thus, a deflection of the probe element).

Such a probe often has a power source in the form of one or more batteries for its energy supply. There is a constant desire to increase the availability performance of such probe systems, which is why there is an effort to maximize the service life of the voltage sources.

European Patent No. 1 557 639, for example, describes a battery-operated probe, where the intention is to prolong the service life of the batteries in particular by the use of a voltage transformer, which ultimately improves the availability of the respective probe, because standstill times due to exhausted batteries are less frequent.

SUMMARY

Example embodiments of the present invention provide a probe and a method for operating a probe, in which the availability of a probe is increased.

According to example embodiments of the present invention, the probe has a power source for its energy supply. The power source is connected electrically to a voltage transformer. The voltage transformer is controllable by a device for monitoring the input power of the voltage transformer, a voltage being able to be generated at the output of the voltage transformer which is higher than the output voltage of the power source. Moreover, a charge storage, which is chargeable electrically with the aid of the voltage transformer, is connected electrically to the output of the voltage transformer. The probe is configured such that: an output current pulse is able to be delivered by the charge storage at defined intervals to a load having a current demand variable over time, especially having a pulse-shaped current demand; a mean power to be fed to the charge storage is ascertainable for a subsequent time interval; the magnitude of the mean input power to be drawn from the power source by the voltage transformer is specifiable as a function of this ascertained mean power, and the voltage transformer is controllable accordingly.

Following the control, the mean input power is then able to be supplied to the voltage transformer, i.e., a mean input current may be transferred by the voltage transformer from the power source to the charge storage.

Advantageously, the load may be in the form of a transmitting stage, so that an electromagnetic signal is able to be generated by the transmitting stage.

In the following, the device for monitoring the input power may be arranged, for example, as a CPU. The power source may be implemented as a direct current source, especially as one or more batteries. The batteries may include a non-rechargeable batteries and/or rechargeable batteries. According to the terminology customary in physics, the term power should be understood to be an energy, e.g., electrical energy, specific to a time interval.

Furthermore, one or more capacitors, or one or more electrochemical double-layer capacitors may be used as charge storage, for example.

The voltage transformer may include a switch, particularly in the form of a transistor, which is connected electrically to the device for monitoring the input power. This electrical connection is used in particular to control the switch along the lines of a pulse-width modulation or a pulse-frequency modulation.

In particular, the probe may include a circuit for determining a voltage applied to the input of the voltage transformer. Alternatively or additionally, the probe may include a circuit for determining a voltage applied to the charge storage.

The device for monitoring the input power, thus, for example, a CPU, includes a circuit for determining a voltage applied to the input of the voltage transformer and/or a circuit for determining a voltage applied to the charge storage.

Moreover, example embodiments of the present invention provide a method for operating a probe. The probe has a power source for its energy supply, the power source being connected electrically to a voltage transformer, and the voltage transformer being controlled by a device for monitoring the input power. In this context, the voltage transformer generates a voltage at its output which is higher than the output voltage of the power source. Furthermore, a charge storage, which is charged electrically by the voltage transformer, is connected electrically to the output of the voltage transformer. In each case, the charge storage delivers an output current pulse at defined intervals to a load or consumer of electrical energy having a current demand variable over time. In addition, a mean power to be fed to the charge storage is ascertained for a subsequent time interval. The magnitude of the mean input power which is to be removed or drawn from the power source by the voltage transformer is specified as a function of this ascertained mean power. The voltage transformer is controlled by the device accordingly, so that the mean power to be fed is supplied to the charge storage.

The load may represent a transmitting stage, so that in each case, an electromagnetic signal is generated by the transmitting stage owing to the output current pulse delivered at defined intervals.

The voltage applied to the input of the voltage transformer may be determined, and an electric input current which is to be drawn by the voltage transformer from the power source may be specified as a function of this applied voltage and the mean input power, and the voltage transformer is controlled by the device accordingly, and is supplied with or traversed by the input current specified.

During the time in which the voltage applied to the input of the voltage transformer is determined, the power source may be disconnected from power consumers of the probe, especially from the voltage transformer, so that a voltage is determined at reduced load for the power source, i.e., a no-load voltage of the power source is determined.

The voltage applied to the charge storage may be determined. The mean power to be fed to the charge storage for a subsequent time interval is ascertained on the basis of the determined voltage applied to the charge storage. To ascertain the mean power to be fed to the charge storage, in particular, the voltage applied to the charge storage may be compared to a predefined setpoint value for the voltage in question. After suitable signal processing, the applied voltage may be available as a digital value.

The voltage transformer may be controlled with the aid of pulse-width modulation.

The mean power to be fed to the charge storage may be ascertained for a time interval ΔT, which is defined according to the relationship $\Delta T = n \cdot T$. In this context, T represents the interval at which the charge storage in each case delivers an output current pulse to a load, and n should be understood as a natural number greater than or equal to 1. For example, n is a number smaller than 10.

Moreover, an electric input current which the voltage transformer draws off from the power source may flow over a period of time of at least 0.75 T within interval T. In particular, the period of time may amount to at least 0.85 T, e.g., at least 0.90 T.

The electric input current which the voltage transformer draws from the power source may be held constant over a period of time of at least 0.75 T within interval T. In particular, the period of time may amount to at least 0.85 T, e.g., at least 0.90 T.

Likewise, the electric power which the voltage transformer draws from the power source may be held constant over a period of time of at least 0.75 T within interval T. In particular, the period of time may amount to at least 0.85 T, e.g., at least 0.90 T.

Intervals T may be selected to be equal.

Defined intervals T may have a length in the range between 5 ms and 100 ms.

A period of time within which the output current pulse is delivered to the load may be at least 10 times smaller, e.g., at least 100 times smaller than the interval to the delivery of the next output current pulse.

In particular, the probe described herein may provide that the batteries are usable for a longer time, i.e., that more energy of the batteries is usable, because an exceedingly careful removal of the electric power from the battery is possible.

Further features and aspects of example embodiments of the present invention are described in more detail below with reference to the appended Figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically illustrates a probe system.

FIG. **2***a* is a schematic circuit diagram for a circuit in a probe.

FIG. **2***b* is a schematic circuit diagram for a voltage transformer.

FIG. **3***a* shows a graph having output current pulses and output powers, respectively, delivered from a charge storage, plotted against time.

FIG. **3***b* shows a graph having the voltage at the charge storage over time.

FIG. **3***c* shows a graph having the power supplied to the charge storage over time.

FIG. **3***d* shows a graph having the current supplied to the charge storage over time.

FIG. **4***a* shows a graph having two voltages applied alternatively to the voltage transformer plotted against time.

FIG. **4***b* shows a graph having the input power which is drawn by the voltage transformer from the power source plotted against time.

FIG. **4***c* shows a graph having two input currents flowing alternatively into the voltage transformer plotted against time.

FIG. **5***a* shows a graph having the voltage at the charge storage over time.

FIG. **5***b* shows a graph having the power supplied to the charge storage over time.

FIG. **5***c* shows a graph having the input power which is drawn by the voltage transformer from the power source plotted against time.

FIG. **5***d* shows a graph of the current flowing into the voltage transformer plotted against time.

FIG. **6***a* shows a graph of the voltage applied to the voltage transformer plotted against time.

FIG. **6***b* shows a graph having the input power which is drawn by the voltage transformer from the power source plotted against time.

FIG. **6***c* shows a graph of the current flowing into the voltage transformer plotted against time.

FIG. **7** shows a schematic flowchart of the method.

DETAILED DESCRIPTION

FIG. **1** shows a probe **1** which may be clamped into a machine tool using a clamping cone. For measuring purposes, a cylindrical feeler **1.1** having a probing contact sphere at one end is provided on probe **1**.

The probe system also includes a transceiver unit **2** which is fixed in position on a stationary component **3** of the machine tool, so that probe **1** is thus mobile with respect to transceiver unit **2**, thus, is movable relative thereto.

In the exemplary embodiment shown, six transceiver elements **1.2** are distributed over the circumference of probe **1**, each secured so as to be offset by 60° along a circumferential line on probe **1**. With the aid of transceiver elements **1.2**, electromagnetic signals, e.g., infrared signals, may be emitted which are able to be received by transceiver unit **2**. In the same manner, a corresponding communication starting from transceiver unit **2** to transceiver elements **1.2** on probe **1** is possible. In the exemplary embodiment illustrated, so-called ready signals B and probe signals A, in particular, are able to be transmitted by probe **1**.

FIG. **2** shows a schematic circuit diagram of a circuit as is situated within probe **1** on a printed-circuit board according to a first exemplary embodiment. Accordingly, the circuit includes a power source **12** which, in the exemplary embodi-

ment shown, includes two lithium batteries having a rated voltage of 3.6 V in each case, so that one may speak of a direct current source here, as well. The lithium batteries are connected in parallel, so that in the ideal case, voltage or power source **12** provides a voltage U_{12} of 3.6 V. The negative pole of power source **12** is connected to ground. Power source **12** is used to supply energy to, e.g., a sensor unit **16**, a CPU **17**, a transmitting stage **15** and a receiving stage **18**. Transmitting stage **15**, upstream from which is a charge storage **14**, may also be denoted as a load having a current demand variable over time. A capacitor having a capacitance C_{14} of 300 μF is used as charge storage **14** in the exemplary embodiment illustrated. Alternatively, a plurality of parallel-connected capacitors may be used, as well. The circuit also includes an RC filter circuit, including a resistor **21** and a capacitor **22**.

In order to make a sufficiently high voltage available for the respective components, the circuit has voltage transformers **13**, **23**. Power source **12** is connected electrically to a voltage transformer **13** and supplies it with electrical energy. Accordingly, voltage transformer **13** is thus connected between power source **12** and the specified load, thus, transmitting stage **15**. According to FIG. **2***b*, voltage transformer **13** includes a capacitor **13.1**, a coil **13.2**, a transistor **13.3**, as well as a diode **13.4** and a further capacitor **13.5**. These components are interconnected in accordance with FIG. **2***b*. In the exemplary embodiment illustrated, capacitors **13.1**, **13.5** in each case have a capacitance of 10 μF. Voltage transformer **13** is able to generate a voltage U_{13out} which lies above an input voltage U_{13in}, thus, above voltage U_{12} of power source **12**.

Transistor **13.3** is controlled by CPU **17** in a manner that a pulse-width modulation PWM may be carried out. When transistor **13.3** is switched on, the current through coil **13.2** increases and energy is stored in it accordingly. As soon as transistor **13.3** is switched off, the coil feeds charge storage **14** via diode **13.4**. Thus, input power P_{13in}, which voltage transformer **13** draws from power source **12**, may be monitored or controlled by CPU **17**.

According to FIG. **2***a*, downstream from a further voltage transformer **23**, the circuit includes two voltage limiters **19**, which provide output voltages U_{19}, U_{20} that are used simultaneously as input voltage for sensor unit **16** and for CPU **17**, respectively. Since the electric current which flows through resistor **21** is very small, the input voltage into receiving stage **18** can be equated in good approximation with voltage U_{19}.

In order to transfer probe **1** from a battery-saving stand-by mode to a measuring-operation mode, a corresponding activation signal is dispatched by stationary transceiver unit **2**. The activation signal is converted by receiving stage **18** of probe **1** from an infrared signal to an electrical signal which is then relayed to CPU **17**. Thereupon, corresponding commands go from CPU **17** to the relevant components in probe **1**, so that the probe system, i.e. the probe, is transferred into the measuring-operation mode.

To signal that the measuring-operation mode is running, the probe transmits a ready signal B at defined intervals T, in the present case, a constant interval T of 20 ms between the sending of two temporally adjacent ready signals B during normal operation being predefined by CPU **17**. In FIG. **7**, in which a flow chart for the method for operating probe **1** is represented schematically, the generating of ready signal B is shown as step I.

FIG. **3***a* shows a timing diagram with respect to the sending of output current pulses I_{14out} which are delivered by charge storage **14** at intervals T=20 ms to transmitting stage **15**. Due to the arrival of output current pulse I_{14out}, transmitting stage **15** generates an electromagnetic signal that is subsequently received by transceiver unit **2**. For the time being, the intention is to discuss only the emitting of ready signals B which are represented by the solid vertical lines, therefore, for example, the four left output current pulses I_{14out} in FIG. **3***a*, thus for $t<t_0$. Corresponding to output current pulse I_{14out}, an electric power P_{14out} is supplied to transmitting stage **15**, as shown by the short horizontal lines in conjunction with the ordinate on the right in FIG. **3***a*. The periods of time τ in which an output current pulse I_{14out} exists amount to approximately 20 μs. For these brief periods of time τ, a comparatively high current on the order of 8 A flows into transmitting stage **15** during an output current pulse I_{14out}. Likewise, power P_{14out} removed from charge storage **14** is relatively high during these periods of time τ.

FIG. **3***b* shows the characteristic of voltage U_{14} at charge storage **14**. In response to each emission of a ready signal B, voltage U_{14} decreases by a few 100 mV, and then rises again over the following 20 ms corresponding to interval T. Actual voltage U_{14} at charge storage **14** is determined after the dispatch of ready signal B. This measure is indicated as step II in the flow chart according to FIG. **7**. In this context, according to FIG. **2***a*, voltage U_{14} is supplied to CPU **17**, CPU **17** including an analog-digital converter and a voltage-divider circuit, so that a 12-bit value is generated there as information about the level of voltage U_{14}.

Moreover, its capacitance C_{14} is read out from a memory of CPU **17**, as well as a setpoint value U_{14Set} for voltage U_{14} at charge storage **14** (step III in FIG. **7**).

Next, energy ΔE to be fed is then calculated by CPU **17** according to the formula

$$\Delta E = \tfrac{1}{2} \cdot C_{14} \cdot [(U_{14Set})^2 - (U_{14})^2]$$

as represented in FIG. **7** as step IV.

After that, time interval ΔT, during which a mean power P_{14in} to be fed to charge storage **14** is to be applied, is read out from the memory of CPU **17**. Likewise, a stored value η for the efficiency factor of the circuit in question (step V according to FIG. **7**). Since ΔT=T was selected in the present case, first of all, interval T, which is stored in CPU **17**, is read out.

Mean power P_{14in} to be fed during a next time interval ΔT=T is then ascertained, using the formula

$$P_{14in} = \Delta E / \Delta T$$

With ΔT=T, it follows for the first exemplary embodiment that:

$$P_{14in} = \Delta E / T$$

Taking into account a value η for the efficiency factor of the circuit in question, in step VI according to FIG. **7**, the level of mean input power P_{13in}, which is to be drawn into voltage transformer **13**, i.e., is to be taken from power source **12** during an interval T, is specified according to the following relationship:

$$P_{13in} = P_{14in} / \eta,$$

where $0<\eta\leq 1$.

In the next step (step VII in FIG. **7**), voltage U_{13in} actually applied to voltage transformer **13** is determined at a time highlighted with dots. Usually, this voltage U_{13in} is largely constant, since as a rule, voltage U_{12} at the output of power source **12** does not fluctuate in this brief time. The time characteristic of voltage U_{13in} is shown in FIG. **4***a*. The voltage is likewise determined in a circuit of CPU **17** with the aid of an analog-digital converter (see also FIG. **2***a*).

Since in normal operation, during the continuous emitting of ready signals B, thus, in FIGS. **3***a* to **3***d* and **4***a* to **4***c* during time $t<t_0$, a constant mean power P_{14in} is also drawn from

voltage transformer **13**, mean input power P_{13in} drawn from power source **12** is constant, as well.

With knowledge of the necessary level of input power P_{13in}, input current I_{13in} to flow through voltage transformer **13** may be ascertained for present voltage U_{13in} by the relationship

$$I_{13in}=P_{13in}/U_{13in}$$

according to step VIII in FIG. **7**.

A specific pulse-no-pulse ratio for the pulse-width modulation is set by CPU **17** as a function of input current I_{13in} to be set for a following period of time according to interval T. Consequently, voltage transformer **13** is thus controlled by CPU **17** in accordance with previously ascertained input power P_{13in}, which was averaged over interval $\Delta T=T$ (see FIG. **2***a* and step IX in FIG. **7**). Therefore, CPU **17** represents the device for monitoring input power P_{13in}.

According to the time characteristic as shown in FIG. **4***b*, input power P_{13in} is then drawn off or removed from power source **12**. Consequently, power P_{14in} is supplied to charge storage **14** according to the characteristic in FIG. **3***c*, that is, a current I_{14in} which corresponds to the characteristic according to FIG. **3***d* will flow into charge storage **14**. According to the exemplary embodiment, input power P_{13in} in each instance remains constant over entire interval T during time $t<t_0$. In this manner, a minimal loading of power source **12** may be achieved. In the same manner, maximum occurring input current I_{13in} is minimized (FIG. **4***c*), which leads to a reduction in losses. In the exemplary embodiment illustrated, input current I_{13in} amounts to approximately 8 mA in this operating state. Therefore, constant electric input current I_{13in}, which voltage transformer **13** draws from power source **12**, thus always flows within interval T of 20 ms. In the same manner, electric power P_{13in}, which voltage transformer **13** draws from power source **12**, is held constant within entire interval T.

Provided that no probing occurs, probe **1** will transmit ready signals B repeatedly at intervals T, which are subsequently received by transceiver unit **2**.

If feeler **1.1** is deflected, a digital signal (change of a voltage level from high to low) is then generated in sensor unit **16**. This signal is transmitted to CPU **17** where it is processed. The signal, processed by CPU **17**, is then routed to transmitting stage **15**, which generates probe signal A in the form of electromagnetic rays or signals. In the exemplary embodiments illustrated, the electromagnetic signals take the form of infrared signals; however, radio signals, for instance, may also be used. Probe signals A are received by stationary transceiver unit **2**. Inside transceiver unit **2**, the infrared signals are converted into electrical signals and conditioned. Finally, the conditioned electrical signals arrive via a cable **2.2** at stationary sequential electronics, where they are further processed.

According to the exemplary embodiment, a probing contact is detected at instant $t=t_0$ which, as described above, results in the transmitting of a probe signal A by transmitting stage **15** to transceiver unit **2**. The electrical energy necessary for this is drawn largely from charge storage **14**, so that at instant t_0, an output current pulse I_{14out} thus flows out of charge storage **14** (see FIG. **3***a*) and correspondingly, at $t=t_0$, voltage U_{14} at charge storage **14** drops according to FIG. **3***b*. Since at instant t_0, charge storage **14** has not yet reached its setpoint charge, that is, at instant t_0, U_{14} is less than U_{14set}, voltage U_{14} drops off further than was the case in normal operation during the periodic transmitting of ready signal B. However, at $t=t_0$, voltage U_{14} lies above a predefined minimum voltage U_{14min}, so that proper operation of the probe is therefore not endangered. Output current pulse I_{14out}, which is followed by a dispatch of a probe signal A, is represented by a broken line in FIG. **3***a*. In the present exemplary embodiment, this output current pulse I_{14out} is greater than output current pulses I_{14out}, represented with solid lines, which are necessary for transmitting ready signals B. The same observation holds true for applied power P_{14out}.

After a probe signal A has been dispatched, further transmission of a signal, e.g., a probe signal A or a ready signal B, is blocked within interval T in the exemplary embodiment illustrated.

After the dispatch of ready signal B, actual voltage U_{14} at charge storage **14** is then determined again at instant $t=t_1=t_0+T$, and energy ΔE to be fed is calculated according to the formula $\Delta E=\frac{1}{2}\cdot C_{14}\cdot[(U_{14Set})^2-(U_{14})^2]$. Since voltage U_{14} at charge storage **14** is comparatively low at instant t_1, a higher value than before is now calculated for energy ΔE to be fed. Thus, a mean power $P_{14in}=\Delta E/T$ to be fed to charge storage **14** is ascertained analogously to the method described above, since T remains unchanged.

Correspondingly, at instant t_1, taking value η for the efficiency factor into consideration, the magnitude of mean input power $P_{13in}=P_{14in}/\eta$, which must be removed or drawn off by voltage transformer **13** from power source **12** during next interval $T=t_2-t_1$, is calculated, and input current I_{13in} to be fed into the voltage transformer is specified. Following that, a specific pulse-no-pulse ratio is set by CPU **17** for the pulse-width modulation. Since voltage U_{13in} has remained unchanged, a higher input current I_{13in} (FIG. **4***c*) is drawn from power source **12** in the period of time between t_1 and t_2. Correspondingly, current I_{14in} (FIG. **3***d*) supplied to charge storage **14**, and supplied mean power P_{14in} (FIG. **3***c*) increase within the period of time between t_1 and t_2, as well. Consequently, at instant $t_2=t_1+T$, voltage U_4 at charge storage **14** has setpoint value U_{14Set} (FIG. **3***b*).

After that, ready signals B are dispatched again at intervals T during normal operation, so that the probe system operates as in period of time $t<t_0$ described above.

For the power source **12**, it is possible to use different batteries, for example, which, according to FIG. **4***a*, are able to supply different voltages U_{13in}. U^*_{13in}. For the case where $U_{13in}>U^*_{13in}$, the result is $I_{13in}<I^*_{13in}$, since mean input power $P_{13in}=P^*_{13in}$ to be fed into voltage transformer **13** remains the same, see FIGS. **4***b* and **4***c*. Current I_{14in} is largely independent of the level of voltages U_{13in}. U^*_{13in}.

In a further exemplary embodiment, illustrated in FIGS. **5***a* through **5***d*, the probe system is operated analogously to the first exemplary embodiment, so long as the probe is transmitting only ready signals B ($t<t_0$). In this operating state, thus, after the transmitting of a ready signal B, voltage U_{14} at charge storage **14** is raised at intervals T in the direction of setpoint value U'_{14Set}, setpoint value U'_{14Set} being set somewhat higher in the second exemplary embodiment than setpoint value U_{14Set} of the first exemplary embodiment. As soon as a probing contact takes place, in the diagrams according to FIGS. **5***a* through **5***d*, at instant $t=t_0$, ultimately the transmitting of probe signal A from transmitting stage **15** to transceiver unit **2** is triggered, and the electrical energy necessary for this purpose is drained from charge storage **14**, so that at $t=t_0$, voltage U_{14} at charge storage **14** drops. Since at instant t_0, voltage U_{14} is less than U'_{14set} in the second exemplary embodiment, as well, voltage U_{14} drops off further than was the case during the periodic sending of ready signals B. After the dispatch of probe signal A, further transmission of a signal, thus a probe signal A or a ready signal B, is prevented within interval T in the second exemplary embodiment, as well.

As in the first exemplary embodiment, after the dispatch of ready signal B, at instant $t=t_1$, actual voltage U_{14} at charge storage **14** is likewise determined in the second exemplary embodiment. However, energy $\Delta E'$ to be fed is calculated according to the formula

$$\Delta E' = \tfrac{1}{2} \cdot \{C_{14} \cdot \tfrac{1}{2}[(U'_{14Set})^2 - (U_{14})^2]\}$$

(here $\Delta E' = \tfrac{1}{2}\Delta E$ applies; incidentally, this relationship is true in the second exemplary embodiment for all instants at which actual voltage U_{14} at charge storage **14** is determined).

Thus, a power to be fed to charge storage **14** is ascertained according to the formula $P'_{14in} = \Delta E'/T$.

Correspondingly, the magnitude of input power $P'_{13in} = \Delta E'/(T \cdot \eta) = P'_{14in}/\eta$ which voltage transformer **13** must draw from power source **12** is calculated, and input current I'_{13in} to be fed into voltage transformer **13** is specified. CPU **17** sets a specific pulse-no-pulse ratio for the pulse-width modulation as a function of input current I'_{13in} determined beforehand. Accordingly, power P'_{14in} supplied to charge storage **14** increases within the period of time between t_1 and t_2, however, not to the extent as was the case in the first exemplary embodiment (see FIG. **5***b*).

Accordingly, the level of voltage U_{14} at charge storage **14** approaches setpoint value U'_{14Set} asymptotically, as shown in FIG. **5***a*. Since probe **1** is operable without difficulty at a voltage U_{14}, which, for example, is 60% of U'_{14Set}, the fact that purely arithmetically, voltage U_{14} does not completely reach setpoint value U'_{14Set} plays no role for the perfect operation of probe **1**. Thus, in the second exemplary embodiment, the period of time for the feeding of the electrical energy is increased without, however, there having been a drop below the necessary minimum voltage U_{14min} at charge storage **14**. For the case when one or more probing processes take place within the period of time between t_1 and t_3, an appropriate automatic readjustment of input current I'_{13in} to be fed into the voltage transformer would then be carried out, so that even in this case, there would not be a drop below the necessary minimum voltage U_{14min} at charge storage **14**.

A third exemplary embodiment is connection with FIGS. **6***a* through **6***c*. Output current pulses I_{14out} are delivered by charge storage **14** to transmitting stage **15** analogously to the first exemplary embodiment, thus, according to FIG. **3***a*. In similar manner, FIGS. **3***b*, **3***c* and approximately, additionally **3***d* are applicable for the third exemplary embodiment, as well. Voltage U_{13in} applied to voltage transformer **13** is to remain unchanged relative to the first exemplary embodiment, as shown in FIG. **6***a*.

In contrast to the preceding exemplary embodiments, however, input power P''_{13in} is now set to zero for an extremely short period (FIG. **6***b*), that is, the supply of input current I''_{13in} fed in is interrupted briefly. In each case, actual voltage U_{13in} is determined precisely at these instants, so that the no-load voltage of power source **12** is quasi measured here. Voltage U_{13in} determined in this manner is thus the basis for the calculation of the level of mean input current I''_{13in} and the level of mean input power P''_{13in}, respectively, which are to be drawn by voltage transformer **13** from power source **12**.

The result is that a battery becoming weaker as power source **12** is not brought immediately to breakdown by the charging of charge storage **14**. The reason is that if voltage U_{13in} is determined under load, in the case of a weak battery as power source **12**, it is lower than the no-load voltage. However, at lower voltage U_{13in}, input current I_{13in} to be fed in is calculated to be higher, and CPU **17** would control voltage transformer **13** such that it would draw a higher input power P_{13in} from power source **12**. Correspondingly, a weak battery as power source **12** would quickly break down completely. In accordance with the method of the third exemplary embodiment, it is possible to achieve at least a delayed breakdown of power source **12**. For the case that power source **12** recovers again, this method is even able to prolong the service life of the battery as the power source **12** considerably.

Otherwise, the third exemplary embodiment corresponds to a great extent to the two first exemplary embodiments.

The representations in FIGS. **3***a* through **6***c* are not true to scale, but rather are intended to only qualitatively point out temporal relationships.

What is claimed is:

1. A probe, comprising:

a feeler;

a sensor unit;

a CPU;

a power source adapted to supply energy;

a voltage transformer electrically connected to the power source and adapted to generate a voltage, at an output of the voltage transformer, higher than an output voltage of the power source;

a device adapted to monitor input power and to control the voltage transformer; and

a charge storage device electrically connected to the output of the voltage transformer, the charge storage device electrically chargeable by the voltage transformer;

wherein the charge storage device is adapted to deliver an output current pulse at defined intervals to a load;

wherein the load includes a transmitting stage adapted to generate an electromagnetic signal so that ready signals and probe signals are transmittable by the probe;

wherein the sensor unit is adapted to generate a digital signal in response to deflection of the feeler and to transmit the digital signal to the CPU, the CPU adapted to process the digital signal and route the processed digital signal to the transmitting stage, the transmitting stage adapted to generate the probe signal as an electromagnetic ray and/or signal;

wherein the probe is adapted to transmit a ready signal at defined intervals to signal that a measuring-operation mode is running; and

wherein the device is adapted to ascertain a mean power to be fed to the charge storage for a subsequent time interval, to control the voltage transformer in accordance with the ascertained mean power to be fed to the charge storage for the subsequent time interval and a level of a mean input power, to be drawn by the voltage transformer from the power source, the level of mean input power being specifiable as a function of the ascertained mean power.

2. The probe according to claim **1**, wherein the voltage transformer includes at least one of (a) a switch and (b) a transistor, electrically connected to the device.

3. The probe according to claim **1**, further comprising a circuit adapted to determine a voltage applied to an input of the voltage transformer.

4. The probe according to claim **1**, further comprising a circuit adapted to determine a voltage applied to the charge storage device.

5. The probe according to claim **1**, wherein the device includes at least one of (a) a circuit adapted to determine a voltage applied to an input of the voltage transformer and (b) a circuit adapted to determine a voltage applied to the charge storage device.

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